
SuperCDMS 25 kg Experiment

Fermilab Program Advisory Committee
March 30, 2007

Blas Cabrera - Stanford University & KIPAC
Spokesperson SuperCDMS Collaboration

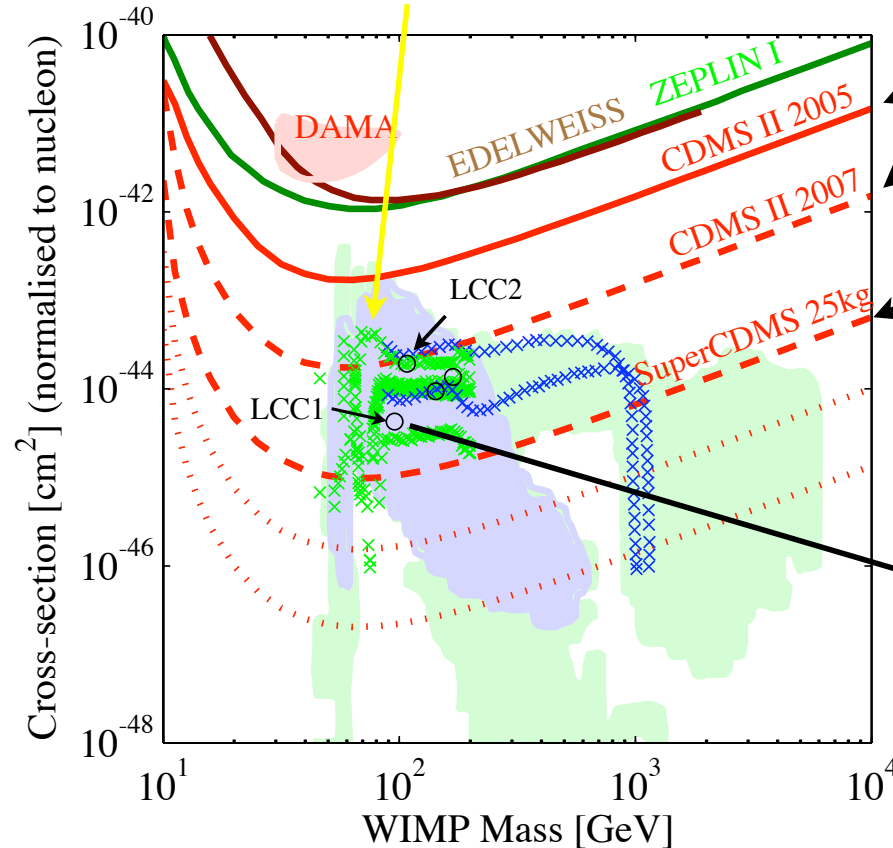
Outline

- Exciting science reach for direct detection experiments
 - We strongly endorse P5 and DM SAG recommendations to expand field.
- CDMS-II Five Tower run operating stably (cold for 9 months)
 - Already x3 exposure gain, on track for x8 sensitivity gain by early 2008
- SuperCDMS 25 kg Experiment ready to go and SNOLAB ready
 - Demonstrated 1" thick detectors would achieve additional x15 by 2012
- We have strong recommendations from review panels
 - P5 recommends funding SCDMS 25 kg and expanding funding of field
 - DM SAG agrees with P5 if funding expanded
 - Fundamental technology differences between CDMS & noble liquids
- Funding for joint NSF and DOE project
 - Approval of DOE proposal for SuperCDMS detectors (pending)
 - Action on NSF proposal for SuperCDMS 25 kg Experiment (pending)
 - DOE proposal for SCDMS 25 kg Exp (line item Mar 07 for FY09 start)

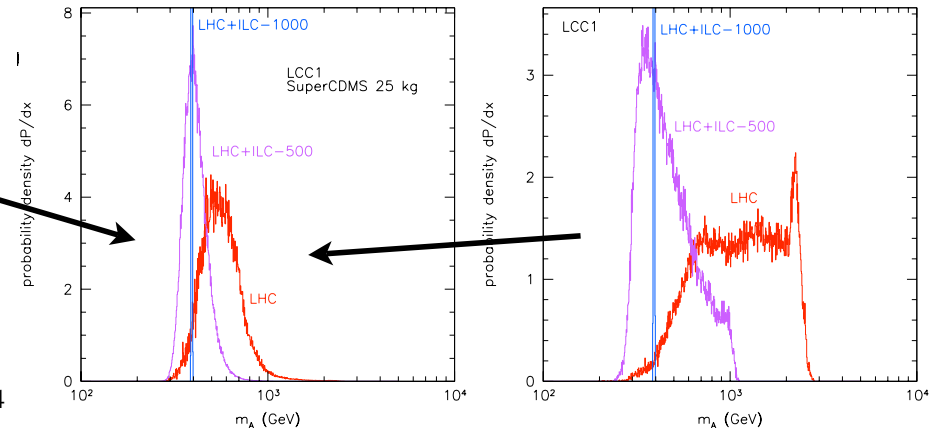
Scientific reach of SuperCDMS 25 kg

- Explore very interesting region which is complementary to LHC

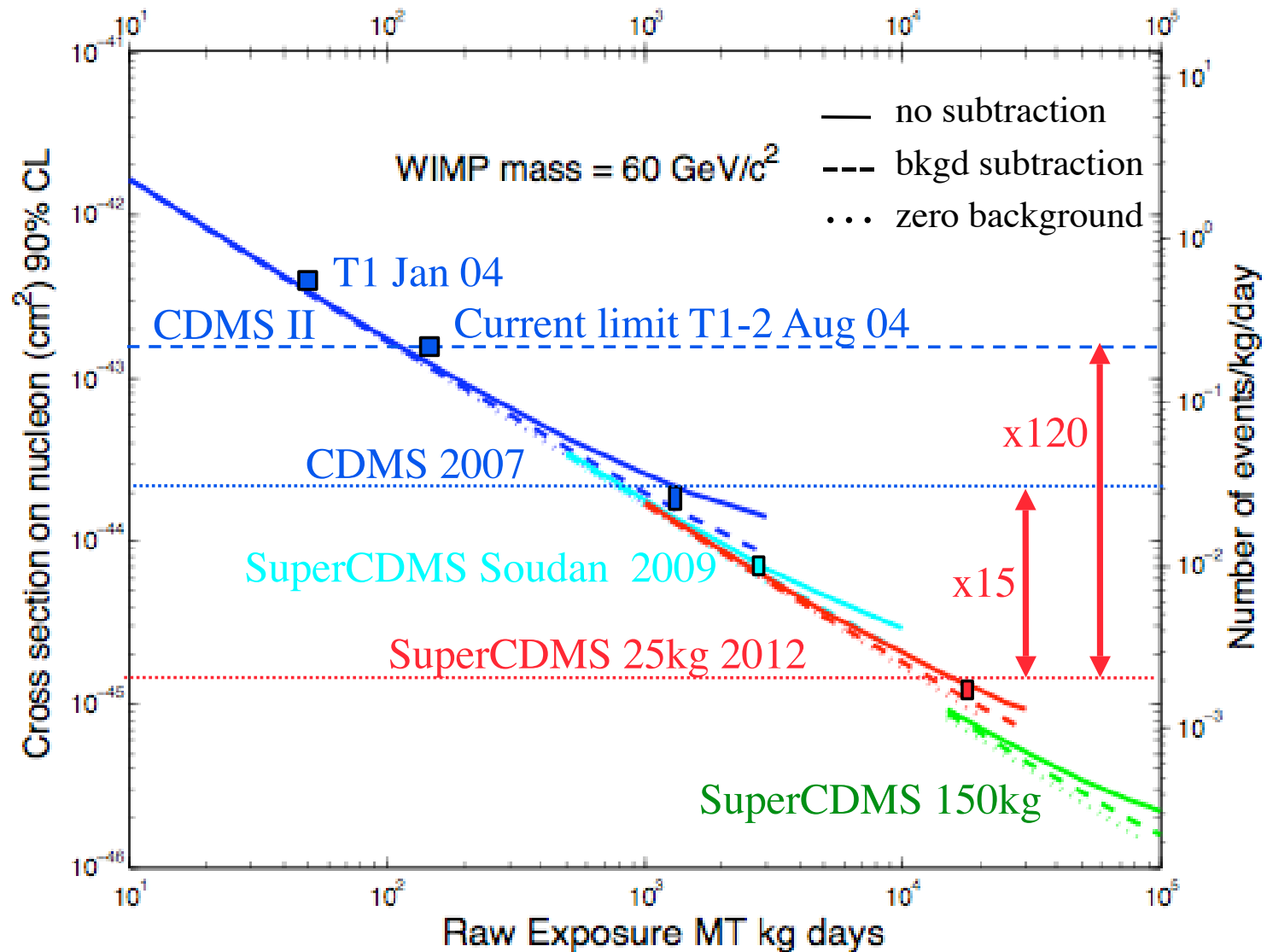
high discovery potential now including 5 events for LCC2



Experiment	Cross-section sensitivity
CDMS II 2-T (2005)	$1.6 \times 10^{-43} \text{ cm}^2$
CDMS II 5-T (2007)	$2.1 \times 10^{-44} \text{ cm}^2$
SuperCDMS Detectors 2-ST at Soudan (2009)	$7.2 \times 10^{-45} \text{ cm}^2$
SuperCDMS 25 kg 7-ST at SNOLAB (2012)	$1.3 \times 10^{-45} \text{ cm}^2$

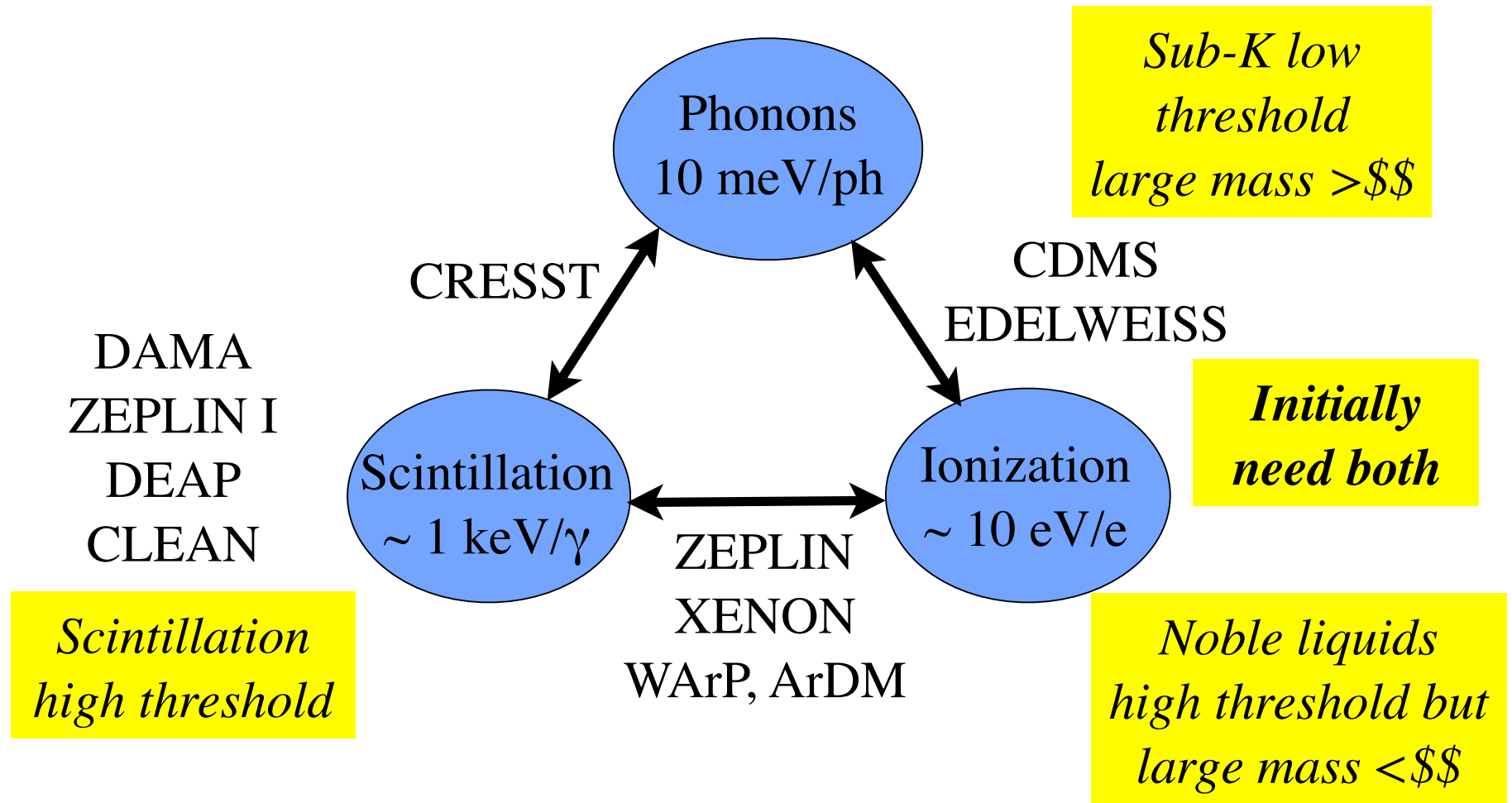


Sensitivity reach with full bkgd analysis



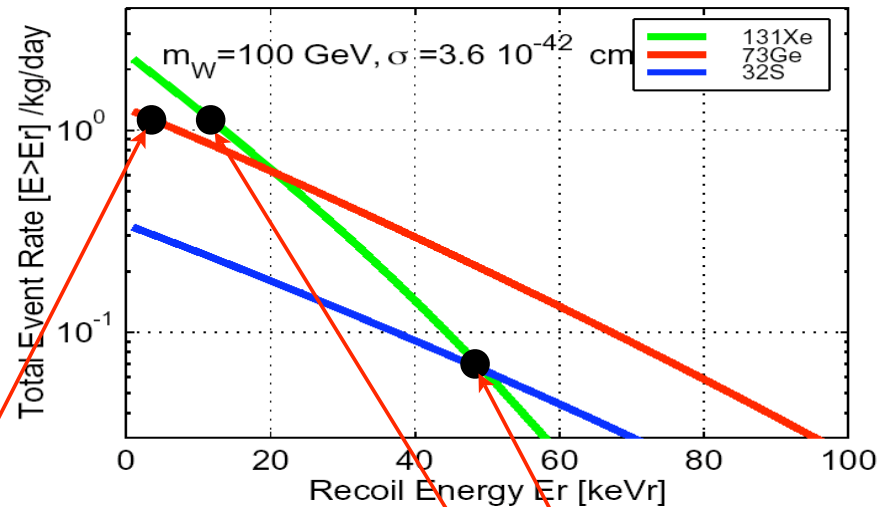
Discrimination strategies

- Most particle physics experience in MeV range
- Direct detection requires keV scale

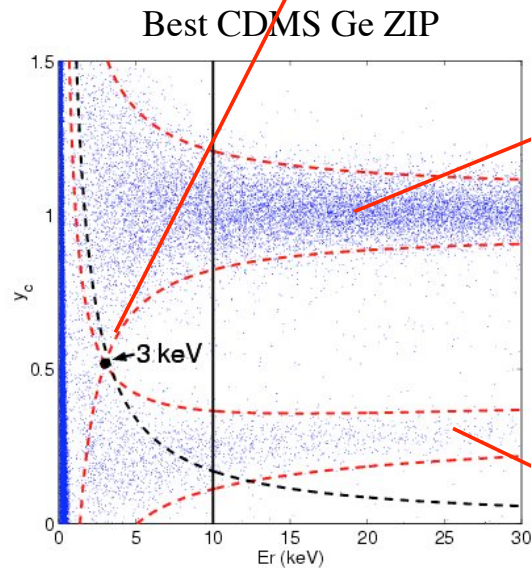


Compare CDMS with noble liquids

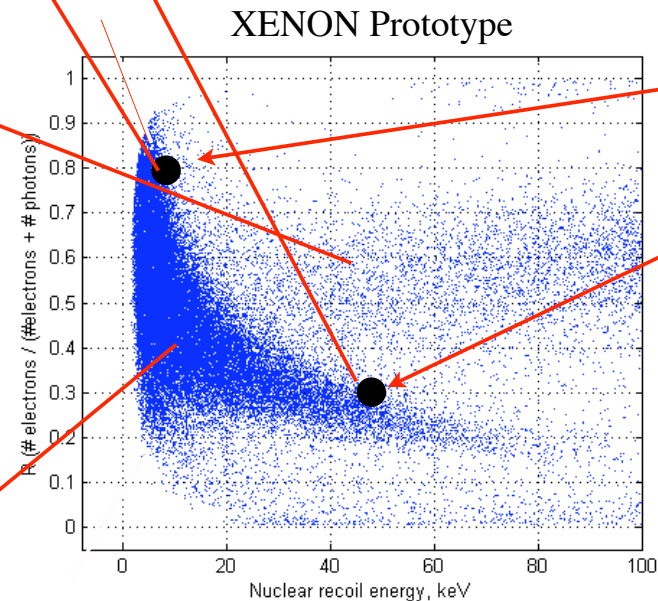
Best resolution from SCDMS experiment allows better discovery potential



In the end, the tails of the background distributions determine the sensitivity



gammas
counting statistics
n-recoils



99% discrimination to below ~10 keV
overlap starts at ~50 keV

for more detail see
<http://www.physics.ucla.edu/hep/dm06/talks/shutt.pdf>

Proposal to DOE and NSF

SuperCDMS 25 kg Experiment

The SuperCDMS Collaboration

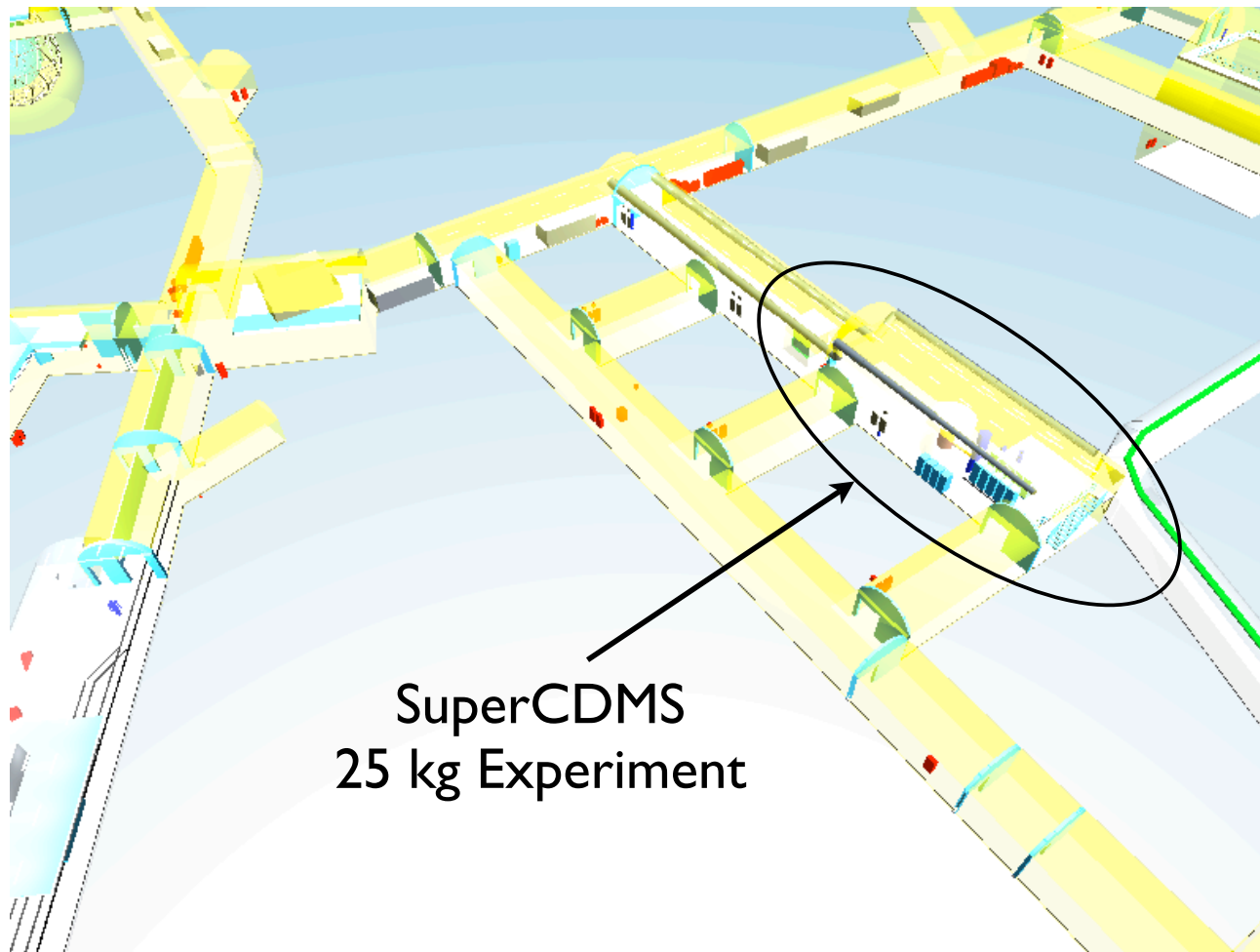
California Institute of Technology
Case Western Reserve University
Fermi National Accelerator Laboratory
Massachusetts Institute of Technology
National Institute of Standards and Technology, Boulder
Queen's University, Canada
RWTH Aachen, Germany
Santa Clara University
Stanford University
University of California at Berkeley
University of California at Santa Barbara
University of Colorado at Denver and Health Sciences Center
University of Florida
University of Minnesota

- Spokesperson: Blas Cabrera
Co-spokesperson: Dan Akerib
Project Manager: Dan Bauer
Chair of Board: Bernard Sadoulet

SuperCDMS ready to go

- Demonstrated fabrication of improved detectors
- Cryogenic system conceptual design complete
 - Engineering Design is underway
- SNOLAB ready for occupancy by early 2008
 - location for SuperCDMS has been settled
- Additional $\times 15$ sensitivity reach by end of 2012.
 - time scale realistic based on past performance

SuperCDMS in Expanded Ladder Lab



Baseline detector for SuperCDMS

CDMS-II ZIPs:

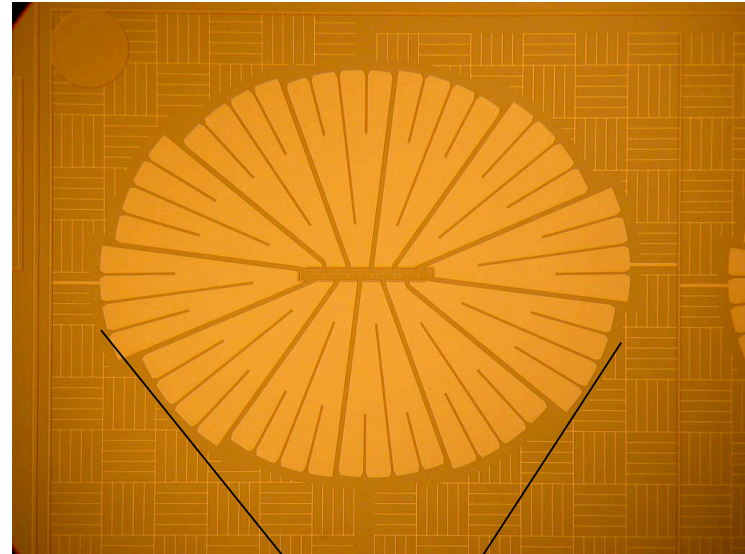
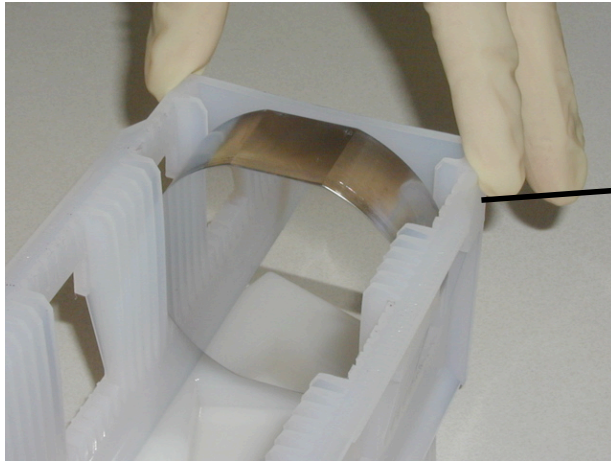
3" dia x 1 cm \Rightarrow 0.25 kg of Ge

Existing ZIPs

SuperCDMS ZIPs:

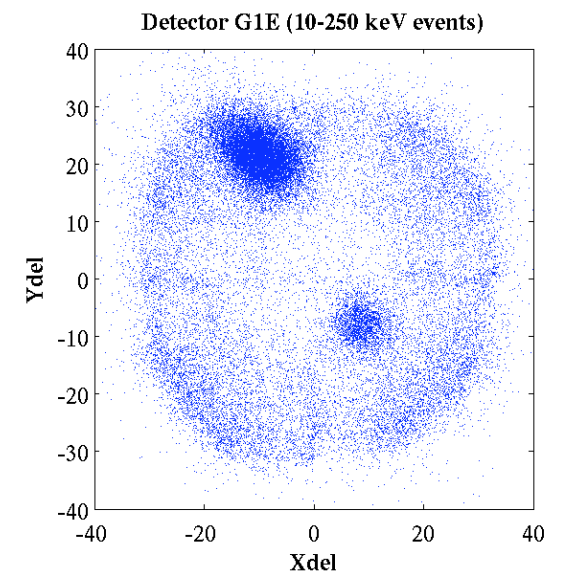
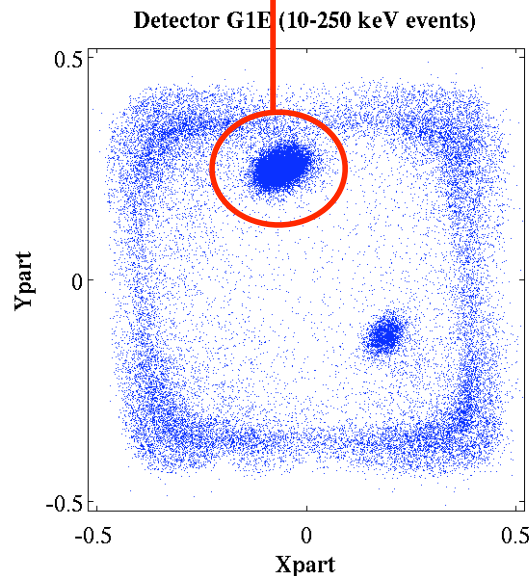
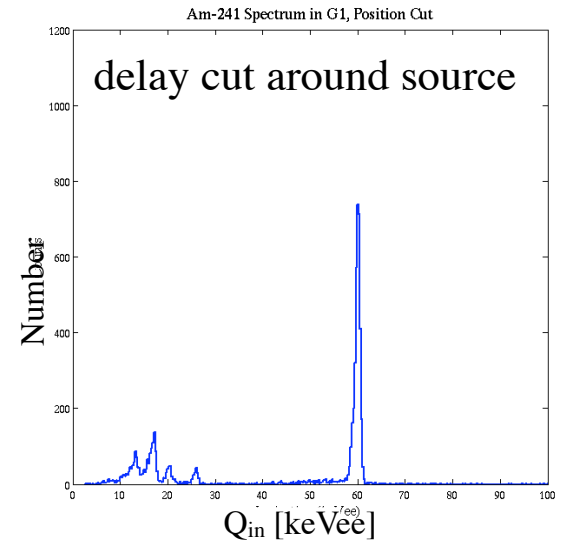
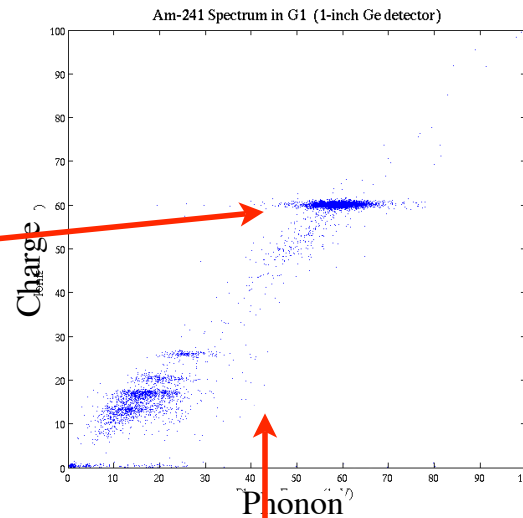
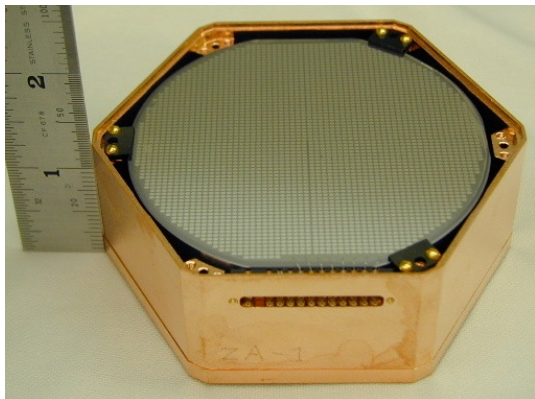
3" dia x 1" \Rightarrow 0.64 kg of Ge

ZIPs for
SuperCDMS



Data from UCB/Case TFs for Ge 1" ZIP

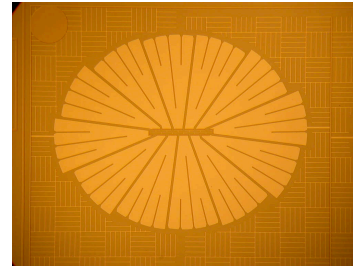
- First data from 1" Ge ZIP showing ^{241}Am 60 keV gamma events in phonon vs charge



Improved background rejection and reduction

Background rejection	$\times 4$
Analysis discrimination	$\times 2$
Background reduction	$\times 5$
Total Improvement	$= \times 40$
Production rate per kg	$\times 5$

Table 2: Targeted improvement factors over CDMS II advanced analysis levels (see Section 3.2) to achieve SuperCDMS 25 kg sensitivities with zero background from internal sources. The cosmogenic fast-neutron background is eliminated by the SNO-LAB overburden of 6000 mwe.



Increase phonon collection area $\times 2$ and new H-a-Si electrodes suppress charge back-diffusion $\times 2$

Expect at least an additional $\times 2$ from advanced timing analyses

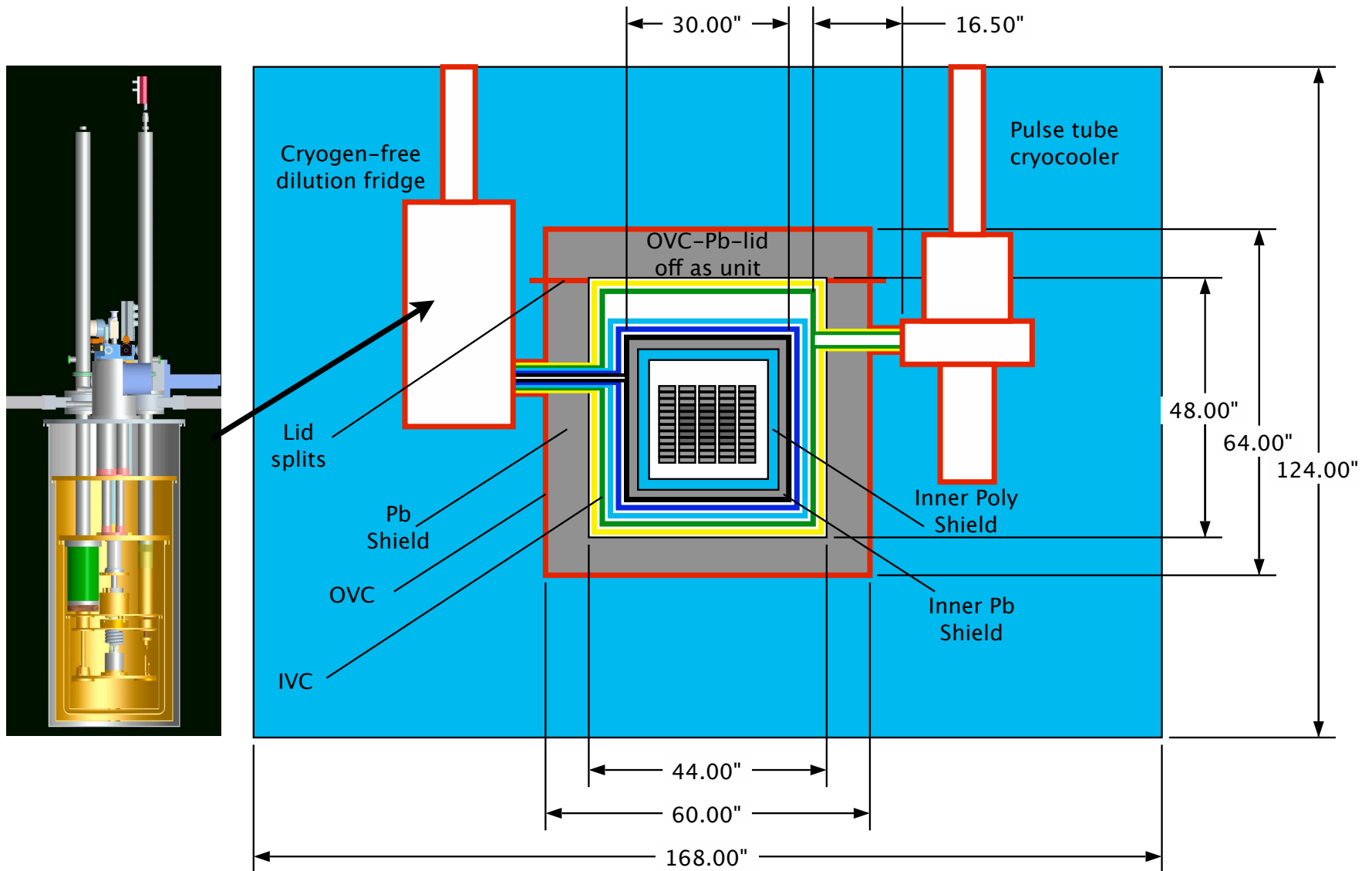
Expect $\times 2.5$ from additional thickness and $\times 2$ from better control of R_n

Need $\times 20$ of this $\times 40$ total for the SuperCDMS 25 kg target background

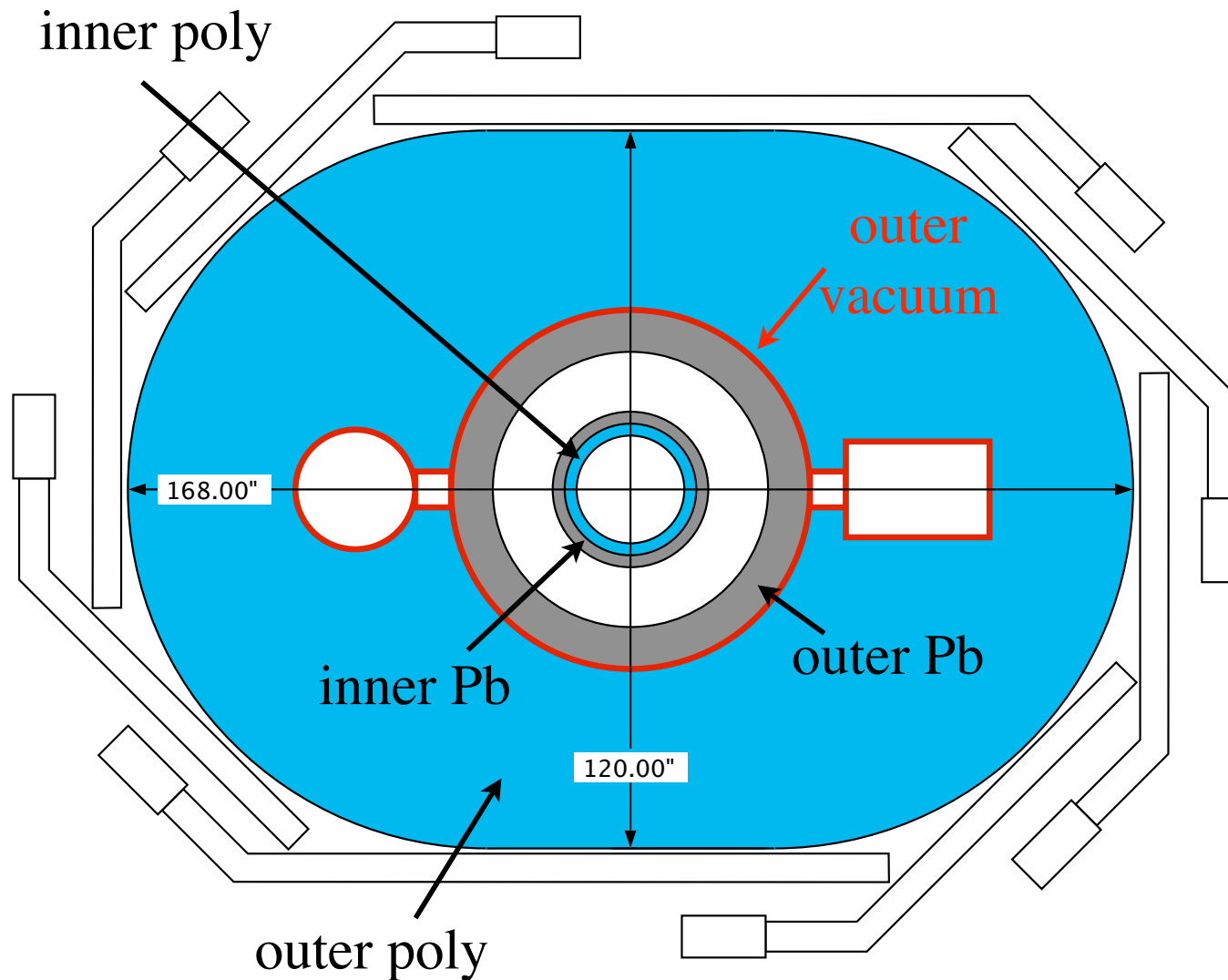
Expect $\times 2.5$ from additional thickness and $\times 2$ from improved fabrication efficiency

- to meet SuperCDMS 25 kg goals only need $\times 20$ actual performance gain out of $\times 40$ predicted gain

Cryogenic System is Cryogen Free

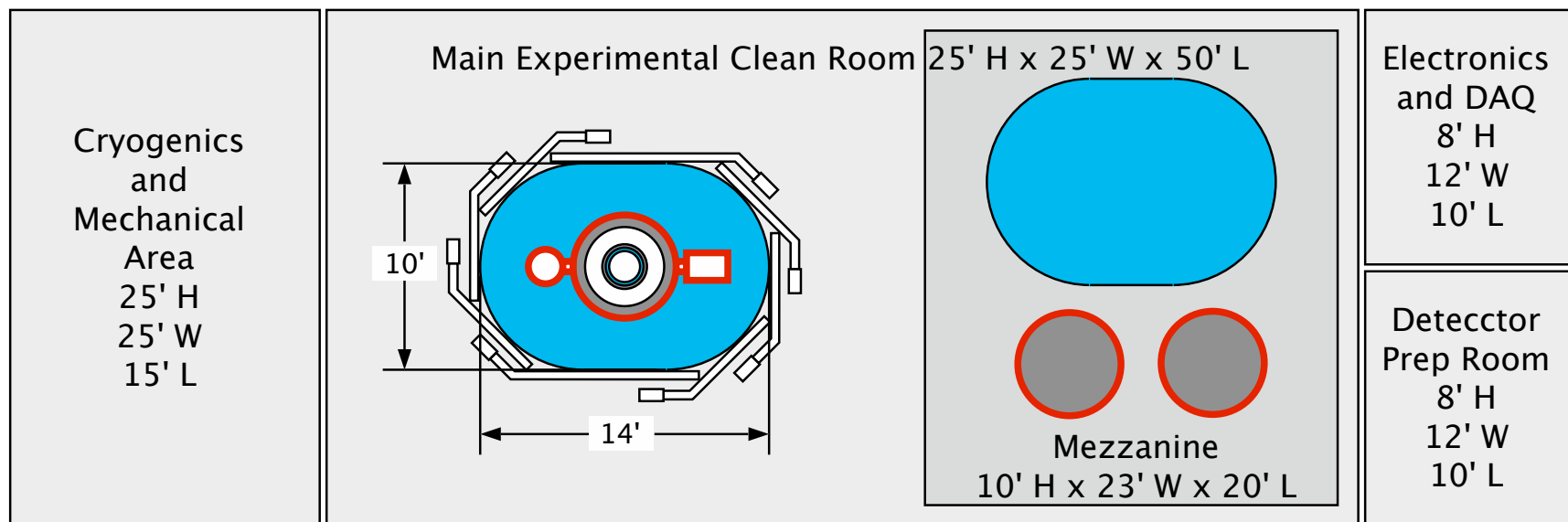


Plastic Scintillator Veto similar to Soudan



Infrastructure at SNOLAB

- Similar layout to our installation at Soudan but with greatly improved dust control.
- Crane coverage for (de)assembly of shield, veto and cryo-system



EPP2010 Recommendation

- **Action Item 4: Scientific priorities at the interface of particle physics, astrophysics, and cosmology should be determined through a mechanism jointly involving NSF, DOE, and NASA, with emphasis on DOE and NSF participation in projects where the intellectual and technological capabilities of particle physicists can make unique contributions. The committee recommends that an increased share of the current U.S. elementary particle physics research budget should be allocated to the questions identified below.**
 - Three major questions in astrophysics and cosmology research could lead to discoveries with potentially momentous implications for particle physics:
 - The direct detection of dark matter in terrestrial laboratories, ...
 - The precision measurement of the cosmic microwave bkgd polarization, ...
 - The measurement of key properties of dark energy.
 - The United States has already established itself as a leader at the interface of particle physics, astrophysics, and cosmology. Since current commitments to this area from the particle physics budgets are relatively modest compared to the full program, it is the sense of the committee that they should be built up to a level approximately two to three times the current level.

P5 Recommendation

- **Recommendations Regarding a Dark Matter Program**
- The CDMS experiment is mature, and is now dealing with the technical issues associated with advancing an already well-developed, well-understood technique into larger-scale implementation. Assuming that the experiment continues to demonstrate adequate background rejection, we recommend full support for the 25kg implementation. This is part of a vigorous international program, which will likely profit from cross checks between different techniques.

DM SAG Presentation (slides 44)

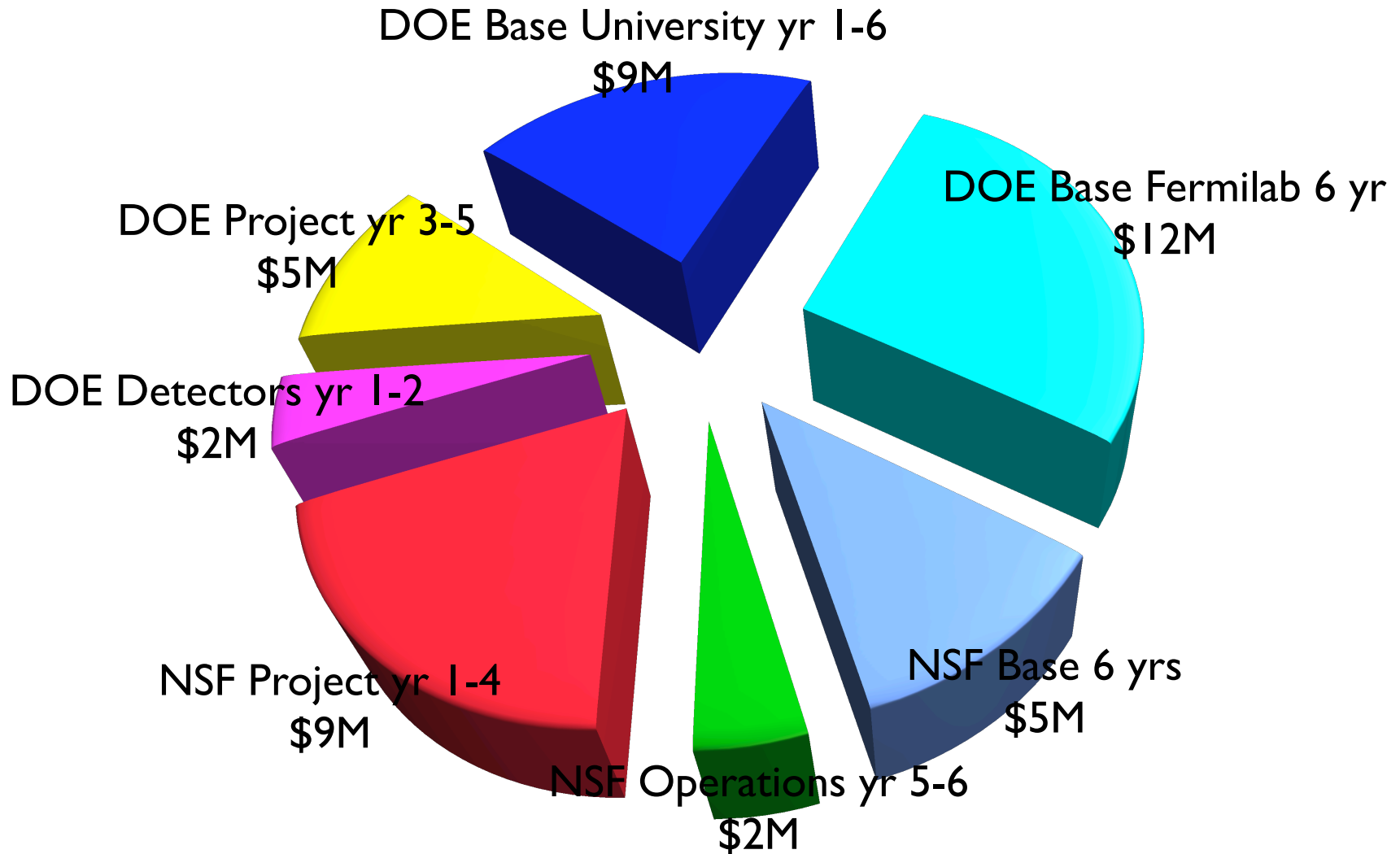
- **Recommendation 1: Program and Funding**

- We recommend that the U.S. advance the search for dark matter using a variety of physical and technical approaches. U.S.-led experiments currently lead the world in sensitivity of the direct detection searches for both WIMPs and axions. We recommend that this leadership be preserved. This requires, in addition to supporting the running and improvement of existing detectors, that the R&D for the next stage of technology development be strongly supported with a goal of steady progress towards ton-scale and larger detectors.
- To realize this program on an optimal time scale, the committee recommends that DOE and NSF increase funding for the direct detection of dark matter from the present ~\$2-3M to ~\$10M annually. The prospect of detecting dark matter while the LHC is operating amply justifies this increase. Such a figure is also consistent with the recommendations of P5 and EPP2010.

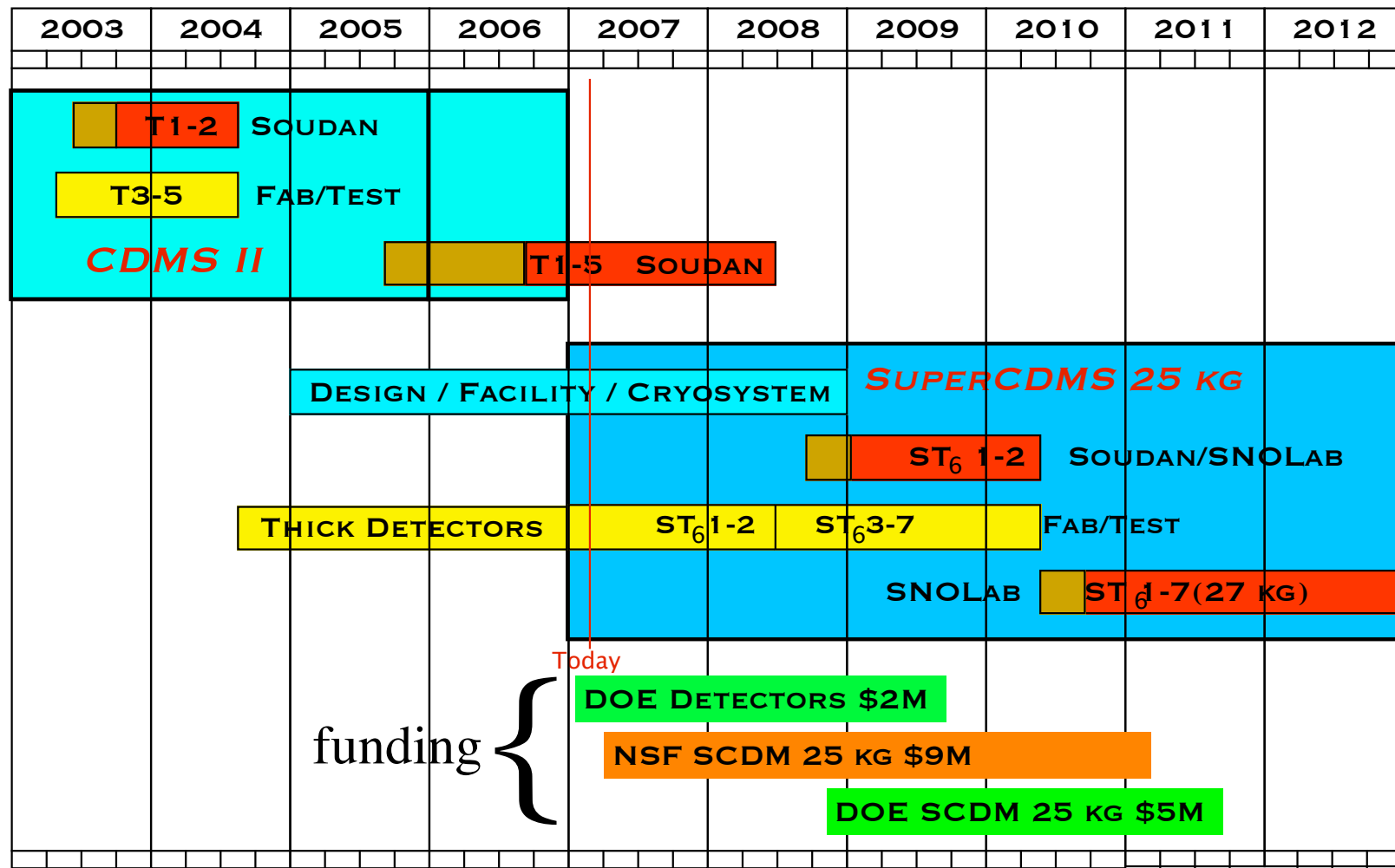
DM SAG Presentation (slide 45)

- **Recommendation: CDMS**
-
- The sub-panel recommends the completion and operation of CDMS-II and the funding of two SuperCDMS supertowers at the Soudan site. If dark matter funding is increased to the range of that suggested in Recommendation 1, we support the design and construction of the necessary refrigeration system for SuperCDMS at SNOLAB. If not, and funding is not sufficient for the rest of the program we have outlined, we recommend that the decision to go forward with SuperCDMS in SNOLAB be contingent upon a full evaluation of the field to be completed by mid-2009.

Budget Summary



Schedule and funding



Conclusion

- Soudan Towers 1&2 leads field with spin-independent limits PRL 2006 and neutron spin dependent limits PRD RC 2006.
- Soudan Towers 1-5 now has x3 over all previous exposure and will run into 2008 for total x8 improved sensitivity. We could see signal!
- EPP2010, P5 and DM SAG, strongly recommend expansion of the funding of the dark matter search field (independently of CDMS): because of importance of science, connection to LHC, and maintaining US leadership.
- WE ARE READY TO PROCEED WITH THE SuperCDMS 25 kg EXPERIMENT NOW, WITH AN ADDITIONAL X15 IMPROVED SENSITIVITY BY 2012.
- WE ARE EXPECTING:
 - approval of \$2M DOE detector project
 - approval of \$9M NSF SuperCDMS 25 kg Experiment
 - line item for DOE \$5M joint funding for FY09
- WE REQUEST FROM FERMILAB PAC APPROVAL FOR FERMILAB ROLE IN SuperCDMS 25 kg Experiment.